Statement of

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National Advisory Committee for Aeronautics

on H. R. 3377

before

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Subcommittee No. 3

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It is a privilege to appear before this committee again to discuss the proposed aeronautical research facilities construction program of the National Advisory Committee for Aeronautics.

The airplane, the missile, and the atomic fission and fusion bombs have changed concepts of military power and the course of history. Our competitor is making a tremendous effort to surpass us; her technology, her scientific manpower, and her stockpile of modern weapons have made great strides. I believe that the quality of our weapons taken as a whole is ahead, but the gap is rapidly closing.

Our national security depends on an adequate number of airplanes and missiles of superior performance. Numbers alone are insufficient unless their performance is at least equal to those our skilled airmen may be called upon to oppose. It is the task of the aeronautical laboratories not only to provide the new ideas necessary to insure superior performance, but at the same time to prove in advance the soundness of the design as a whole. The NACA's work, therefore, falls into two principal categories:

(1) research to furnish new ideas; and (2) the application of new ideas to current military designs in cooperation with industry.

To advance the frontiers of speed, altitude, and range, special research facilities are required. Until recently we have had insufficient knowledge to reproduce the conditions of high speed and temperature experienced in hypersonic flight. We had to be contented with small scale exploration of many ideas. We know now how to proceed with pilot facilities and in some cases with larger facilities which give results immediately applicable in design.

H. R. 3377 reflects NACA's urgent need for additional facilities for research in the hypersonic speed range, and the continuing need for modernizing existing facilities for the solution of new problems in the subsonic, transonic, and supersonic speed ranges. The 1958 construction program totals $44,700,000, summarized as follows:

New facilities for hypersonic research	$20,965,500
Expansion of facilities for nuclear research	5,655,000
Modernization of research facilities	10,936,400
Modernization of supporting technical facilities	6,485,200
General plan and utility improvements	657,900
Total	$44,700,000

3.5-Foot Hypersonic Tunnel

The construction of a 3.5-foot hypersonic tunnel at the Ames Aeronautical Laboratory is proposed to investigate the aerodynamics of aircraft capable of steady level flight at hypersonic speeds. The proposed facility will be capable of duplicating flight Reynolds numbers at Mach numbers from 5 to 10, and flight temperatures at flight Reynolds numbers at a Mach number of 5. The tunnel will accommodate models large enough to permit the scaled duplication of aircraft structural components so that detailed studies can be made of aerodynamic heating on the aerodynamic characteristics of hypersonic aircraft as they occur in flight. As you gentlemen know, aerodynamic heating is one of the foremost problems encountered in flight at hypersonic speeds. The success or failure of a hypersonic aircraft may well depend on how it reacts to the temperatures and heating rates encountered in flight. At present, the design of such vehicles would have to proceed without detailed knowledge of their aerodynamic characteristics since much of the needed design information is not available. This proposed tunnel is designed to provide detailed and integrated studies of all required aerodynamic characteristics under conditions comparable to those that would be encountered in flight. The tunnel will duplicate flight Reynolds numbers and flight air temperatures so that the details of convective heat-transfer to a vehicle may be studied under conditions corresponding to those that would be encountered in flight. Since the nozzle walls of this facility remain cool, the heat radiation from the model surface will approximate that experienced by an aircraft at hypersonic speeds and the counterbalancing effects of convective and radiative heat transfer can be observed as they would occur in flight.

The proposed tunnel will also be used to study the over-all aspects of convective heating for a complete configuration. In this connection, an analysis has been made which demonstrates that a wind tunnel can simulate the heating histories of vehicles in level flight in essentially the same manner that the atmospheric-entry simulator reproduces the heating histories of ballistic-type vehicles. The simulation requires that flight Mach numbers, stream temperatures, and Reynolds numbers be duplicated, and that the essential components of a vehicle be reproduced in scale. A one-tenth scale model tested in the wind tunnel for one minute would simulate the heating experienced by a full-scale vehicle in a flight at a Mach number of 5 over a distance of about 6,000 miles.

In summary, the designer of hypersonic aircraft is confronted with difficult problems in the fields of aerodynamic heating, stability, control, and performance which can be solved only with the aid of detailed and accurate data from tests which duplicate actual flight conditions. Much of the required data could be obtained in the proposed tunnel. The facility will provide test Mach numbers of 5, 7, and 10, and at each of these Mach numbers typical flight Reynolds numbers will be duplicated. The duplication will be adequate for the study of many hypersonic design problems, particularly those of performance and control. The facility will also be capable of operation at stagnation temperatures up to 2,000° F at all Mach numbers.

Hypersonic Blowdown Tunnel

The second facility proposed for basic hypersonic research is a helium blowdown tunnel. Experimental rocket-propelled vehicles are attaining speeds in excess of those which can be studied in existing experimental facilities. The current earth satellite program and military plans for long-range missiles point up the actual need for greater information on phenomena which occur at speeds attainable in outer space. There is no wind tunnel available for testing at Mach numbers much above 10 and the likelihood of an air tunnel achieving Mach numbers much in excess of this appears remote because of the extreme pressures and temperatures required for air.

An analysis of the potentialities of helium as a test medium has shown it to be highly suitable for hypersonic research at speeds far above the capabilities of air tunnels. The practicality of a helium tunnel has also been experimentally demonstrated. While helium does not permit exact simulation of flow conditions for air, for purposes of basic fluid mechanics research, the difference is of little consequence.

The proposed hypersonic blowdown tunnel will use helium as a test medium and will be capable of operating at Mach numbers from 10 to 25.

High-Speed Leg for Unitary Plan Tunnel

The project entitled "High-Speed Leg for the Unitary Plan Tunnel" covers construction of two fixed nozzles previously included as part of the project approved in the fiscal year 1957 construction program. The nozzles had to be deleted to live within the reduced appropriation provided for the project. The project as now contemplated will cover the Mach number range between 10 and 12.

Rocket Systems Research Facility

The Rocket Systems Research Facility project at the Lewis Flight Propulsion Laboratory proposes the construction of two new buildings and the alteration of an existing building to provide research stands, cells, and laboratories.

The increasing application of rocket power plants and the use of new propellants has brought new and pressing problems in controls, pumping, and the interferences caused by close coupling of multiple engine systems. In long range ballistic missiles, these problems are greatly accentuated. Making sure that the missile is directionally on its proper course is only part of the problem; in addition you have to make sure that the missile is travelling at precisely the right speed when the rocket motor burns out. Otherwise, of course, the target will be overshot or undershot. Single rocket engines, each with thrusts much greater than that of present turbojet engines, must be operated together.

The rocket motor of the V-2 burned for about 70 seconds. Purely for illustration, let's say the burning time of one concept of an ICBM might be about three times that, some 200 seconds. During that time -- 3-1/3 minutes -- the fuel and oxidant might be pumped into the combustion chamber at the rate of about a ton a second.

Calculations indicate that if the missile is going to destroy a priority target the rocket motor must operate with a degree of precision which has not been used before in devices of this size or complexity. In five minutes a missile must reach an altitude of 500,000 to 1,000,000 feet, traveling at a velocity of 18,000 miles per hour. If the velocity is 18,005 miles per hour, it misses the target by five miles. Likewise if one percent of the propellant isn't used, the miss may be measured in hundreds of miles.

Pumps for rocket propellants must operate under severe conditions, such as with surging inlet pressure due to boiling of the fluids being handled. Turbines and their gas generators for driving the pumps must be adapted to use the same propellants as the main rocket combustion chamber to avoid the need for separate tanks and flow systems. The proposed facility will be equipped to handle inert fluids such as water and liquid nitrogen for research on flow fundamentals, as well as liquid rocket propellants.

The design of the bearings and seals used in the liquified gas pumps require studies in a new field involving unfamiliar phenomena that have not been significant in usual bearing applications. Among these phenomena are: extreme dangers from leaks in bearings and seals, handling fluids hostile to lubricants and lubrication, and lubrication at temperatures of boiling hydrogen (-424°F).

This proposed new facility will make possible research on these and many other rocket problems. Turbopump research will be directed at providing pumps and turbines that are operable with boiling and corrosive fluids, that deliver large flow rates and high pressures, that have suitable suction characteristics, and that have maximum efficiencies and minimum size and weight. Controls research will have the objectives of accurately controlling the rocket thrust-time relationship, accurately monitoring propellant consumption, obtaining desired fluid flow-pressure-time sequence in the turbopump, and providing a reliable system that operates smoothly, without pulsation, vibration damage, or malfunctioning. Bearing and seal research will be directed at developing bearings and seals which will operate satisfactorily and reliably in corrosive and low viscosity fluids, and at very high as well as at very low temperatures.

Hypersonic Physics Test Area

Research on materials, structures, and aerodynamics at elevated temperatures requires the investigation of problems at all points along the Mach number and temperature scales up to Mach numbers of 20 or more. Experimental equipment and facilities suitable for such investigations, as well as the problems themselves, differ greatly in nature as the speeds and temperatures increase. The development of large-scale devices capable of producing extremely high temperature and at the same time capable of representing correctly other environmental conditions such as speed, gas chemistry, and time durations has not yet been accomplished satisfactorily. For this reason, NACA seeks on a small scale to try ideas for accomplishing such developments while at the same time utilizing for limited research the equipment produced for such trials.

The proposed hypersonic physics test area is designed to facilitate progress in the general area of equipment and technique development in the higher temperature ranges while at the same time providing safe and integrated means for conducting exploratory research at these temperatures. The facilities proposed for the test area include chemical jets providing temperatures up to nearly 11,000°F, and hyper-velocity guns to conduct research relating to problems of missile countermeasures and meteor impact problems.

The five projects I have just outlined are NACA's proposed new facilities for hypersonic research.

Modifications to the Component Research Facility for Nuclear Propulsion

We propose also a modification and extension of the component research facility for nuclear propulsion presently under construction near Sandusky, Ohio. This research facility is for research on components for use in nuclear-powered aircraft under realistic conditions of radiation, temperature, and pressure. The design studies of the reactor show that it will provide an excellent source for high-level radiations.

Experience to date in the aircraft nuclear propulsion program has brought to light the need for extensive auxiliary equipment and laboratory facilities. The results of tests must be analyzed adequately and rapidly, making necessary the addition of more extensive facilities for handling and studying highly radioactive materials than first contemplated. A secondary reflector of beryllium is required to provide a higher and improved flux distribution in the large test holes. A large air supply and emergency power supply is needed to carry on certain types of experiments. A radiation analysis laboratory is required for the study of the effects of radiation on aircraft structures and equipment.

Recent reactor runaway experiments by the Atomic Energy Commission have resulted in a requirement for improved containment of the NACA reactor to insure safety to the surrounding area in event of an accident. The facility under construction has been designed to achieve the larger and more complex containment vessel required. Other modifications are needed to meet the requirements of the Atomic Energy Commission's Safeguard Committee including (1) additional retention basins; (2) additional cooling tower capacity for use as a secondary coolant for some experiments; (3) additional equipment in the primary and secondary water supply systems to provide for safer operation and better continuity of operation; and (4) an additional independent power line to provide for continuity of operation and increased safety to the facility.

Modernization of Research and Technical Facilities

The other items of our proposed construction program are for modernizing existing research and technical facilities and for general plant and utility improvements.

It is proposed to expand the existing propulsion systems laboratory at the Lewis Laboratory by the installation of facilities to investigate the performance of engines up to Mach numbers in excess of 4.5 using the free-jet technique. The facilities recommended will also permit the more extensive use of high-energy fuels in large full-scale engine tests.

A by-pass system for the Ames Laboratory Unitary Plan Tunnel will substantially improve the usefulness and value of the 9- by 7-foot supersonic circuit of this tunnel by eliminating surging of the flow through the compressor which drives air through the two supersonic circuits of the tunnel which is encountered under some conditions, and by reducing power losses in the diffuser, resulting in some increase in maximum Mach and Reynolds numbers.

It is proposed that auxiliary suction be applied to the slotted test section of the Ames Laboratory 14-foot transonic wind tunnel for boundary layer removal. Since the design of the 14-foot transonic tunnel was completed, important advances have been made in transonic wind-tunnel design. The application of auxiliary suction to the plenum chamber surrounding the test section has proven to be the most beneficial of recent improvements to transonic tunnels. This improvement should be applied to the 14-foot transonic tunnel without further delay.

The addition of the boundary-layer removal system will permit the tunnel's effective model size to be doubled, will increase the Mach number limit from 1.2 to 1.4, and will reduce the need for overload operation of the main drive motors over most of the tunnel's speed range.

It is proposed to improve the air flow in the 11-foot transonic tunnel circuit of the Ames Unitary Plan Tunnel. The acquisition of new knowledge on the characteristics of transonic test sections indicates that significant improvements in the quality of the air flow can be achieved by altering the method of venting the test section and by redesigning the by-passed air re-entry region at the downstream end of the test section. The proposed modernization offers the possiblity of a decrease in the Mach number variations in the test section and an improvement in the air flow at the diffuser entrance of sufficient magnitude to result in a decrease in the required tunnel drive power.

It is proposed to modify the Langley Laboratory 26-inch transonic blowdown tunnel by installing an alternate 20-inch square test section to extend the maximum attainable Mach number of the facility from about 1.4 to about 4.0. This tunnel is used primarily for flutter investigations. The nature of the flutter problem at the higher Mach numbers is relatively unexplored and is urgently in need of investigation.

In addition to modernizing the research facilities just discussed, it is also necessary to modernize three of our supporting technical facilities.

The capabilities of the research vehicles used in the conduct of aeronautical research at the Pilotless Aircraft Station at Wallops Island have exceeded the ability of the gound instrumentation to provide full coverage of a research flight. It is essential that modern instrumentation be provided to obtain urgently needed data in the hypersonic speed range. The project covers two tracking radars, telemeter receiving equipment, an increased range Doppler system, and auxiliary equipment.

A data reduction center is required for the expansion and improvement of the automatic data-processing facilities at the Langley Aeronautical Laboratory. The complex problems involved in research at increased flight speeds and altitudes and on new aircraft configurations required for supersonic flight have greatly increased the amount of required data reduction and analysis. The new building will centralize existing data-processing facilities, improve operating efficiency, and provide on-line data-processing service for three major wind tunnels.

The increasing need for structures research at high temperature has made marginal an existing central compressor system at the Langley Aeronautical Laboratory which supplies air to several research facilities. An improved air supply for the internal flow laboratory will permit the installation of the necessary additional compressor capacity.

Plant and Utility Improvements

With regard to general plant and utility improvements, we propose (1) to acquire approximately 115 acres of land adjacent to the Lewis Laboratory to permit the future expansion of research facilities, (2) to install two boilers in the heating plant near the Langley Laboratory full-scale tunnel in place of the eight low-pressure boilers which are nearing the end of their useful lives after more than 15 years of operation, and (3) to construct a new West Area approach road at the Langley Laboratory which is necessitated by the Air Force installation of a runway extension.

Attached to this statement are two tables, one table shows the NACA construction and equipment program for fiscal year 1958 by functions, and the other table summaries the program by laboratory.

Mr. Chairman, we urge the favorable consideration by your Committee of H. R. 3377.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

FUNCTIONAL SUMMARY, CONSTRUCTION AND EQUIPMENT PROGRAM

NEW FACILITIES FOR HYPERSONIC RESEARCH:		
3.5-foot hypersonic tunnel (Ames)	$11,731,000	
Hypersonic helium blowdown tunnel (Langley)	796,600	
High-speed leg for the Unitary Plan tunnel (Langley)	750,000	- $20,965,500
Rocket systems research facility (Lewis)	5,700,000	
Hypersonic physics test area (Langley)	1,987,900	
EXPANSION OF FACILITIES FOR NUCLEAR RESEARCH:		
Modifications to the component research facility for nuclear propulsion (Lewis)		5,655,000
MODERNIZATION OF RESEARCH FACILITIES:		
Expansion of the propulsion systems laboratory (Lewis)	5,800,000	
By-pass air system for the Unitary Plan tunnel (Ames)	100,000	
Boundary-layer removal for the 14-foot transonic tunnel (Ames)	4,435,000	- 10,936,400
Flow improvement in the Unitary Plan tunnel (Ames)	255,000	
Modification of the 26-inch transonic tunnel (Langley)	346,400	
MODERNIZATION OF SUPPORTING TECHNICAL FACILITIES:		
Modernization of instrumentation (Wallops)	2,560,000	
Data reduction center (Langley)	3,067,200	- 6,485,200
Improved air supply for the internal flow laboratory (Langley)	858,000	
GENERAL PLANT AND UTILITY IMPROVEMENTS:		
Land acquisition (Lewis)	300,000	
Central heating system for the East Area (Langley)	209,100	- 657,900
West Area approach road (Langley)	148,800	
TOTAL, FISCAL YEAR 1958 PROGRAM		$44,700,000

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

CONSTRUCTION AND EQUIPMENT PROGRAM, BY LABORATORY

LANGLEY AERONAUTICAL LABORATORY		
High-speed leg for Unitary Plan tunnel	$ 750,000	
Hypersonic physics test area	1,987,900	
Data reduction center	3,067,200	
Improved air supply for the internal flow laboratory	858,000	
Modification of the 26-inch transonic tunnel	346,400	
Central heating system for the East Area	209,100	
Hypersonic helium blowdown tunnel	796,600	
West Area approach road	148,800	
TOTAL (Langley)		$ 8,164,000
AMES AERONAUTICAL LABORATORY		
3.5-foot hypersonic tunnel	11,731,000	
By-pass air system for the Unitary Plan tunnel	100,000	
Boundary-layer removal for the 14-foot transonic tunnel	4,435,000	
Flow improvement in the Unitary Plan tunnel	255,000	
TOTAL (Ames)		16,521,000
LEWIS FLIGHT PROPULSION LABORATORY		
Modifications to the component research facility for nuclear propulsion	5,655,000	
Expansion of the propulsion systems laboratory	5,800,000	
Land acquisition	300,000	
Rocket systems research facility	5,700,000	
TOTAL (Lewis)		17,455,000
PILOTLESS AIRCRAFT STATION		
Modernization of instrumentation	2,560,000	
TOTAL (Wallops)		2,560,000
NACA TOTAL		$44,700,C